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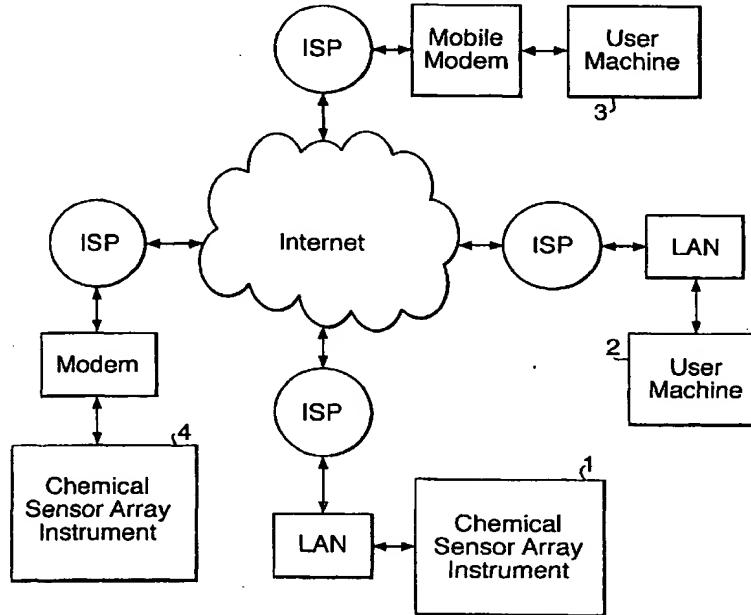
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(54) Title: **CHEMICAL SENSOR ARRAY SYSTEMS**



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(57) Abstract: A chemical sensor array system includes a chemical sensor array and network connection means, thus enabling it be accessed from a remote site or sites. This enables sensor data or other information to be transmitted to a central monitoring site, for example and also permits information to be sent back to the apparatus.



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CHEMICAL SENSOR ARRAY SYSTEMS

This invention relates to chemical sensor arrays systems in which remote communication with a chemical sensor array apparatus is implemented via network connection means.

A chemical sensor array includes a plurality of sensors which, when exposed to a substance to be analysed, provides a response which may be used to identify and/or give the concentration of the substance or otherwise characterise it. Such chemical sensor arrays may sense in the liquid, gas or vapour phase and include as a sub-class those arrays sometimes referred as electronic noses as they operate using odour analysis. Many different sensor technologies are available for inclusion in such sensor array, which may 5 comprise a single sensor technology type or a combination of sensor technology types. For example, the sensors may be mass sensitive, for example, such as those which use bulk acoustic wave or surface acoustic wave techniques. Electronic conductance and capacitance sensors may be, for example, chemo-resistors based on conducting polymer or metal oxide semiconductor materials. The sensors in an array are arranged to give 10 different responses to detected substances, and analysis of the responses is used to characterise the substance. The data is then processed using for example a statistical method such as principle component analysis or multiple discriminate analysis, fuzzy logic, artificial neural network or a proprietary classifier algorithm. The technique or 15 techniques adopted depends on the substance to be sensed and the purpose for which the information is acquired.

Chemical sensor arrays are available as laboratory instruments and may also be used, for example, in quality control applications or manufacturing processes.

According to the invention, there is provided a chemical sensor array system comprising a chemical sensor array apparatus and network connection means for communicating with the apparatus from a remote location.

5 Use of the invention provides Internet connectivity to a chemical sensor array apparatus such that, for example, the sensor data generated and the parameters used to control the apparatus may be accessed remotely via the Internet and in addition or alternatively, a user at a remote site may be able to transfer data, instructions and information to the apparatus, or to a user at the site of the apparatus.

10

Preferably, the system is configured such that a user at a remote site is able to retrieve information from the apparatus such as, for example, sensor data files, diagnostic parameters such as sensor frequency and resistance values, temperature data, flow rate data and humidity measurements, status information and the like. The apparatus is thus in

15 one embodiment preferably configured such that the information is stored in data files which are accessible via the network connection means, for example by links between the network connection means and the data files. Some of the information may in one system in accordance with the invention be transferred to a remote site using file transfer protocol (FTP) whereas other information is transferred using a different protocol or protocols.

20

The system may be configured to enables data and information to be uploaded to the apparatus from a remote site. For example, this information may include instructions to the apparatus, settings and parameter files or communication with personnel servicing or operating the apparatus. The system may also be configured to permit software to be

uploaded to the apparatus from a remote site. The system may include means such that it accepts information, data, software or other forms of communication only from an authorised source. With this safeguard, the communication may be automatically accepted at the apparatus. In other embodiments, the system includes means for refusing some or all 5 such information unless it is specifically confirmed by a user at the apparatus or a user having access to the apparatus via another route. The manufacturer or maintainer of the apparatus may send software upgrades to the apparatus, to modify data collection, data handling, sensor array operation or the like, to improve these aspects, to optimise them, to make new features available, or to provide compensation for changes in operating 10 conditions or sensor operation. It is particularly advantageous where the communication between the manufacturer or service personnel and the apparatus is two way, as it enables analysis of the apparatus performance to be made at a remote site where the manufacturer or servicing engineer is based and then a response made depending on the results of the analysis.

15

A system in accordance with the more efficient data transfer of chemical sensor array data than has heretofore been available, which is significant for chemical sensor array apparatus where large amounts of data are created and require processing.

20 In one advantageous embodiment, the system comprises a plurality of apparatuses located over a distributed region which may be controlled and/or monitored from a central station. The apparatus may be distributed at multiple locations on a site or at multiple sites with a centralised command and control monitoring station.

The invention may provide effectively real-time access to the apparatus for 24 hours a day from a remote site or sites.

Also, apparatus may be located inaccessible, hazardous or hostile locations but may be

5 interrogated at a remote more convenient location without the need for a service engineer
or user to visit the apparatus.

In one advantageous embodiment of the invention, the system includes a data processing site remote from the apparatus and connected thereto via the network interconnection means. The system may be operative to download data from sensor files included in the apparatus with data processing being carried out at the data processing site. The remote data processing site may also implement pre-processing on the raw data, or this may be carried out at the apparatus prior to transfer. The results of the data processing may then be transferred back to the apparatus, reducing the necessity for large storage capacity at the apparatus. The arrangement may also provide feedback to the apparatus, for example, to change sampling times in dependence on the results obtained after analysis. Where a plurality of apparatuses are included in the system distributed over wide geographical areas this enables a centralised set of data-mining or data-fusion algorithms to develop or to generate a global overview of an operation, process or chemical status issue.

20

In one advantageous embodiment, the system is operable such as to configure a terminal at a location remote from the apparatus to reproduce the appearance of the apparatus for ease of use by a user at the remote location. The page displayed at the remote terminal may be configured to match the displays and controls of the apparatus itself, with buttons on the

display, for example, for accessing data or altering parameters at the apparatus. The remote terminal may have a keyboard which is modified on accessing the apparatus to act as if it were a keyboard included in the apparatus, with commands, say, input via the remote keyboard having the same effect as those input at the apparatus keyboard. The user may

5 use the remote terminal for adjusting parameters of the apparatus or accessing information or data provided by the apparatus. In another advantageous embodiment, the system is operative to permit remote monitoring of the sensor array included in the apparatus or other aspects of the system status so as to enable improved product support by the manufacturer of the apparatus. This gives a cost saving through the reduction in number of

10 on-site visits. Status monitoring may also avoid system breakdowns by giving pre-emptive servicing. The manufacturer may also upload software upgrades to the apparatus with no need for posting or delivering of actual media or for the user of the apparatus at the apparatus site to install such software.

15 The remote terminal may be fixed or mobile, for example it may be a mobile telephone with Internet capability.

The manufacturer may also obtain an improved understanding of any design or performance limitations of the apparatus by remote monitoring thereof to give product

20 optimisation and lead to further developments.

The information from the sensor array may be integrated with other process parameters obtained from other sources and combined together, benefiting the customer or end user.

Information concerning the product or process may be made widely available within an organisation by virtue of the network connection means. Such information may be accessed virtually simultaneously and at real-time by a number of users at different locations.

5

Product uniformity, for example, may be improved in a multi-site production process by an operator working from a single desktop. For example, a product may be controlled to meet a standard specification across multiple production plants and/or continents.

10 The system may also advantageously include means for providing feedback. Such feedback may be used to control a process, for example. For example, a sensor may detect change on the headspace of a fermentor and then a valve is signalled to release more substrate into the fermentor.

15 In a system in accordance with the invention, means are included for automatically contacting a remote site or sites when a particular condition is detected. For example, a apparatus may detect a problem with a product batch on analysis of the data and this, may be automatically communicated to the quality department, and the manager of the next process in the production sequence to warn of likely delay and to assist scheduling, and

20 also to the sales group to enable them to warn customers of the delay.

Some ways in which the invention may be performed are now described by way of example with reference to the accompanying drawing in which the sole figure schematically shows a system and variants thereof in accordance with the invention.

A brief description of the technology involved in the interconnection of computers is given to aid understanding and terminology.

The type of data communications facility used is a function of the application. If only two
5 computers are involved and both are in the same room or office, then the transmission facility can comprise just a simple point-to-point connection e.g. wire link, optical fibre. However, if they are located in different parts of a country, public carrier facilities must be used. Normally this involves the public switched telephone network (PSTN) which requires a modem for transmitting data.

10

When more than two computers are involved in the application, a switched communication facility (network) is used to enable all the computers to communicate with one another at different times. If all the computers distributed around a single office or building are connected to a network, this is known as a local area network (LAN). When computers are
15 located in different sites, the resulting network is known as a wide area network (WAN). In most cases the public carrier networks must be used again. However, for some large companies there is sufficient intersite traffic to justify the cost of leasing lines and installing and running a private network.

20 In addition to providing a public switched telephone service, most public carriers now provide a public switched data service. Indeed, such networks, like the PSTN, are now interconnected internationally and have been designed specifically for the transmission of data rather than voice. Consequently, for applications that involve computers distributed around the world, a public switched data network (PSDN) is normally used. Alternatively,

many public carriers are now converting their existing PSTNs to enable data to be transmitted. The resulting networks, which operate in an all-digital mode, are known as integrated services digital networks (ISDNs).

- 5 The Internet is made up of computers/LANs being connected to a public carrier network, which themselves are connected internationally. With the advent of mobile telecommunications it is now possible to connect a computer to the Internet anywhere there is the appropriate mobile service available.
- 10 The physical connection between a LAN and a National PSDN is controlled by a Gateway (router). Gateways are also used to route data through other data communication facilities e.g. satellite.

The Internet is the global association of computers that carries data and makes the exchange of information possible. To send information from one computer to another over the Internet requires the use of Internet Protocols e.g. Transmission Control Protocol/Internet Protocol (TCP/IP), simple mail transfer protocol (SMTP), file transfer protocol (FTP) or Telnet protocol. TCP/IP is the most important of Internet protocols. To send data from one computer to a recipient computer, firstly, TCP breaks down every piece 20 of data (e.g. email) into small packets, each of which is wrapped in an electronic envelope with Internet addresses for both the sender and the recipient. The IP protocol then works out how the data is to pass from one computer to the other, by passing through a series of routers. Each router examines the destination addresses of the packets it receives and then passes the packets on to another router as they make their way to their final destination. If

an email was broken into several packets, then each packet may have travelled a completely separate route. This will not be detected by the user, since the TCP at the recipients computer, identifies each packet and checks that it is intact. Once it has received all the packets, TCP reassembles them into the original order.

5

The World Wide Web is a subset of the Internet, that is a collection of interlinked documents that work together using a specific Internet protocol called HTTP (HyperText Transfer Protocol). Web pages can be exchanged over the Net because browsers (which read the pages) and Web servers (which store the pages) both understand HTTP. Web 10 pages are files that are written in Hyper Text Markup Language (HTML) and stored on a web server. To remotely access web pages a computer connected to the Internet must have a suitable browser e.g. Netscape, Internet Explorer.

Internet Service Providers (ISPs) are companies that provide access to the internet. ISPs 15 serve both large companies and individuals requiring internet connection. ISPs are connected to one another through Network Access Points that are public network exchange facilities i.e. PSDN. The whole or part of an ISP may be the same company as that requiring connection.

20 Chemical sensor array instruments can operate as stand-alone or can be connected to a LAN. In previously known arrangements, if these data files are to be viewed by a user remote from the instrument, the following procedure is used, assuming both the remote and local user have a computer connected to the Internet. Firstly, the data file generated has to be created on or moved to memory drives available to the local computer connected to the

Internet. A local user must then physically send the file across the Internet to the remote computer connected to the Internet. This requires the knowledge of the Internet address (e.g. Internet Protocol address, or email address) of the remote computer on the Internet. The files could be sent as an attachment of an email. The remote user upon receiving the email, must extract the file sent into a suitable location on a memory drive available to their computer. The file must be opened in a suitable software application, compatible with the file type, in order to view the data.

The present invention, in contrast, employs a remote login to the instrument to view the data e.g. a PC anywhere, giving a significant improvement in efficiency in data handling and the other advantages mentioned previously.

Very often the raw data generated by the sensors can be difficult to interpret. In most cases further processing is applied to the data e.g. pattern recognition algorithms for sample classification or event detection. Connecting the instrument to the internet, means that a web site can be generated for an instrument, that provides a user friendly visual interface. Different pages could be set up for viewing different aspects of the data e.g. temp control, flow variation, event detection. This web page (html file) can be updated with new data on regular intervals. Now a remote user can access this information using a suitable browser remotely over the Internet.

The system can also be controlled from the web pages by having data relating to the control parameters setup on a web page.

In this embodiment, the sensor array apparatus includes three separate functional modules, a sensor array module, a sample handling module and a processing module. The processing module provides the following functions:

1. Data acquisition from the sensor module and sample handling module
- 5 2. Storing, logging of raw data
3. Processing data e.g. applying pattern recognition algorithms to the chemical sensor data to discriminate different samples
4. Storing processed data
5. Outputting data e.g. to a display or local network
- 10 6. Control signals are sent to the sensor module and sample handling module. These control the parameters of the sensor environment, or sensor operation, or the method of sample control through the system

The key hardware in such a module may consist of a computer, memory e.g. hard-drive, interface hardware to the sensor and control signals, interface hardware to displays or other peripherals e.g. disk drive, hardware to local networks.

To achieve internet connectivity the processing module within a system must be equipped with hardware to provide a physical link to the internet and hardware to receive and

20 transmit suitable signals compatible with the physical link. The processing module must also be equipped with software that defines the protocols used to provide communication between computers on the Internet e.g. TCP/IP. There must also be software code that converts the data required over the Internet to a file format that can be served (by an Internet server) to a remote browser. The software that provides the server function can be

located on the instrument or on the LAN, WAN or Internet Service Provider to which the instrument is connected. The instrument must also be allocated with an Internet Protocol (IP) address, which is known by those remote users requiring access to the data.

5 Some typical embodiments of the connectivity are shown in the Figure . In the Figure there are four connections made to the internet. The connection marked 1, is a chemical sensor array instrument with the appropriate hardware and software to provide a connection to a LAN. The LAN itself has a connection to the Internet via an ISP. The connection 4, is a chemical sensor array instrument with a dedicated modem link to an ISP. The modem may 10 be incorporated internally to the instrument. The modem may use mobile telecommunications, or a standard telephone line.

Similarly the user may be connected to the Internet via a LAN (2) or via a direct connection using a modem. Referring to the user machine as a client, since this is where 15 the information is served. The client machine may be a stand alone PC, laptop, palmtop or any other computer based instrument with an associated display.

The connections to the internet may be fixed connections or connected only when information is being transmitted.

20

There are different methods available for transferring the information from the Sensor Array Instrument to the client. Some of these methods are described below.

Example 1.

1. The Client emails the remote instrument
2. The remote instrument receives the email
3. The remote instrument recognises keywords embodied in the body of the email, which
5 act as commands.
4. The remote instrument replies to mail according to embedded commands.

Example 2.

This example assumes the remote instrument has a web page and the client has browser
10 software that allows the web page to be read. Assuming the page is written in HTML, the
remote instrument would require access to an HTTP (web) server. Web servers allow you
to serve content over the Internet using the Hyper Text Markup Language (HTML). The
Web server accepts requests from browsers e.g. Netscape and Internet Explorer, and then
returns the appropriate HTML documents. A number of server-side technologies can be
15 used to increase the functionality of a web page e.g. Active Server Pages, Java Server
Pages. Dynamically generated web pages provides a means to update the data displayed in
a web page more frequently.

Assuming a permanent connection to the internet via an ISP. The client requests the web
20 page from remote instrument and the remote instrument sends the latest web page. This
page can be updated with the latest data by exploiting server-side technology.

Example 3.

The web pages for a chemical sensor array instrument could be stored on the ISP web server. Here the client machine requests the instruments web page from the ISP web server. The ISP then sends the web page to the client. However, the remote instrument 5 could send the latest data to the ISP web server e.g. by using File Transfer Protocol. The web page could be dynamically created when requested to process the latest files on the server.

CLAIMS

1. A chemical sensor array system comprising a chemical sensor array apparatus and network connection means for communicating with the apparatus from a remote location.
2. A system as claimed in claim 1 wherein the network connection means is integral with the sensor array apparatus.
3. A system as claimed in claim 2 wherein the sensor array apparatus includes a server which includes the network connection.
4. A system as claimed in claim 1 wherein the network connection means is separate from the sensor apparatus and including a data link between them.
5. A system as claimed in claim 4 wherein the apparatus is connected via a LAN.
6. A system as claimed in any preceding claim wherein the apparatus includes data files which are accessible via links to the network connection.
7. A system as claimed in any preceding claim and including means for uploading information to the apparatus via the network connection means from a remote location.
8. A system as claimed in claim 7 wherein the means for uploading information include a mobile terminal.

9. A system as claimed in claim 7 or 8 wherein the information includes operational settings and commands for the apparatus.
10. A system as claimed in any preceding claim and including means for uploading command information to the apparatus.
11. A system as claimed in any preceding claim and including means for carrying out diagnostics on the apparatus from a remote location via the network connection means.
12. A system as claimed in any preceding claim and including means for uplinking software upgrades to the apparatus via the network connection means.
13. A system as claimed in any preceding claim and including a plurality of apparatuses at different locations.
14. A system as claimed in claim 13 and including a central monitoring station operable to communicate via network connection means with the said plurality of apparatus.
15. A system as claimed in any preceding claim and including a remote data processor site, the system being operable to transfer data from the apparatus via the network connection to the remote data processing site.
16. A system as claimed in claim 15 and wherein the system is operable to transfer results of the data processing via the network connection means to the apparatus.

17. A system as claimed in any preceding claim and wherein the network connection is included in a server, said server being operable to facilitate real-time functions upon access between a remote browser and said server.

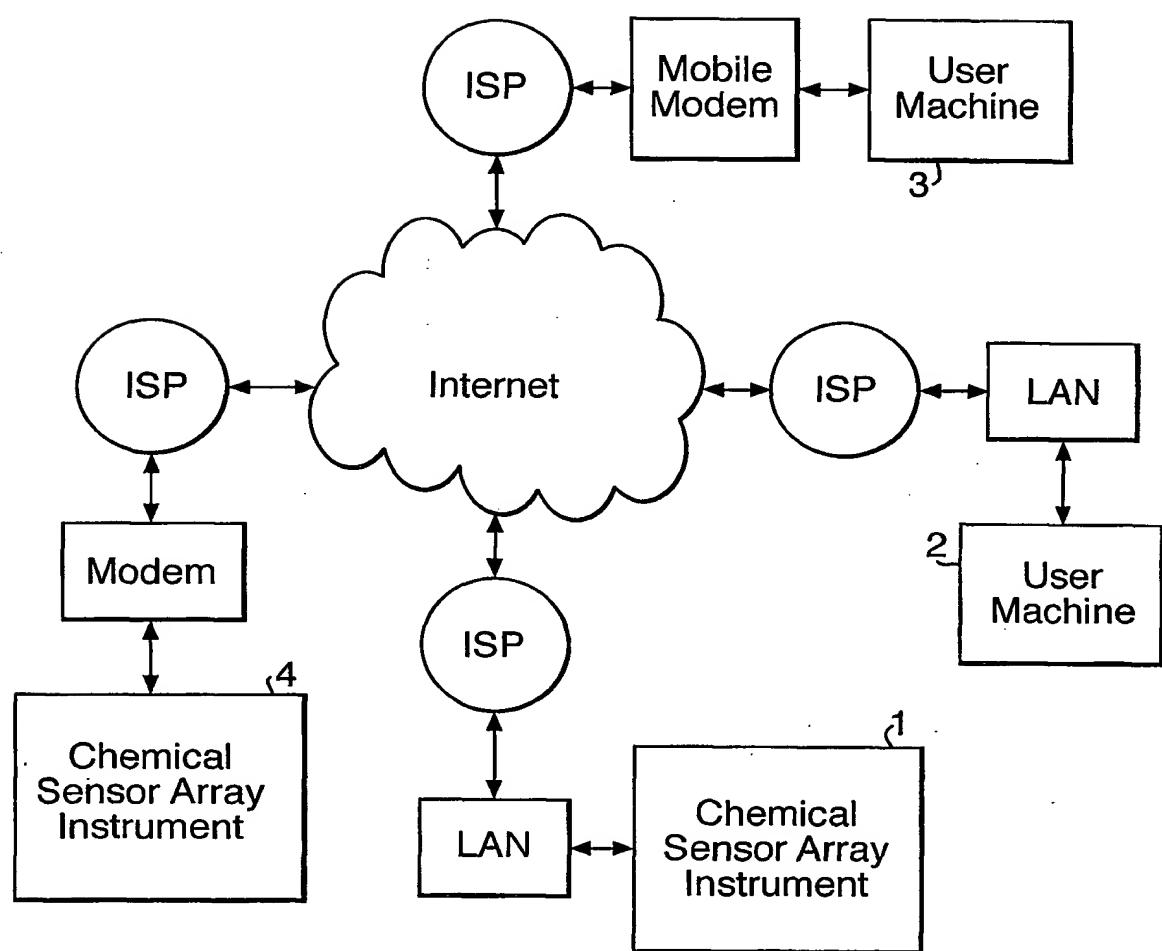
18. A system as claimed in claim 17 wherein said server has an accessible page.

19. A system as claimed in claim 18 wherein the page is hypertext compliant mark-up language page.

20. A system as claimed in claim 18 or 19 wherein an embedded function associated with the page is operable to run at said server when a remote browser accesses the page, to maintain a connection between said server and the remote browser through the network connection means.

21. A system substantially as illustrated in and described with reference to the accompanying drawing.

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SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

national Application No

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A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 IPC 7 G01N G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 53287 A (KOOSH VINCENT ; DICKSON JEFFERY (US); GRUBBS ROBERT H (US); LEWIS N) 21 October 1999 (1999-10-21) page 4, line 9 - line 16 page 24, line 15 - line 27; figures 11,18	1-21
X	WO 00 13010 A (FASANO ADAM M; GEOENVIRONMENTAL INC (US)) 9 March 2000 (2000-03-09) page 5, line 9 -page 13, line 2; figures 1-5	1-21
X	WO 98 59487 A (ENACT HEALTH MANAGEMENT SYSTEM) 30 December 1998 (1998-12-30) claim 1	1-12

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

National Application No
PCT/GB 01/01072

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 99 36771 A (GOOSSENS RENIER J L C ;HEALTH AND SAFETY SYSTEMS HOLD (LU); SCHINK) 22 July 1999 (1999-07-22) the whole document -----	1-21

INTERNATIONAL SEARCH REPORT

Information on patent family members

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